MEAN MONTHLY CHARACTERISTICS OF THE WIND REGIME

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ABSTRACT. The mean characteristics of regular wind patterns were studied to ascertain the differences between true mean monthly values of wind characteristic parameters and the mean values obtained for 24-hours, or from methods used to average values for several days at a time.

The question of what is to be considered as the mean monthly drift is /39
one of the most important such questions from the viewpoint of studying seasonal behavior patterns of the regular wind in the meteor region of the atmosphere. Drift measurements usually are made for an eight to ten day period, followed by measurements of the zonal and meridional components of the wind, in the third or fourth week of each month (this is the manner in which drift measurements were specified in the IQSY program).

Averaged characteristics of the regular wind, obtained over an eight to ten day period, were taken as the mean monthly values. There is no arguing the fact that averaging such as this requires experimental verification. The problem of refining the procedure for obtaining mean monthly characteristics arose primarily because comparison of observation results obtained in different localities made it difficult to interpret results. This was because the measurements often were made on different days. Difficulties such as these obviously are associated with the fact that characteristics of the regular wind can vary greatly from day to day, as Greenhow [1] has noted.

The aim of our investigation was to ascertain the differences between the true mean monthly values of wind characteristic parameters and the mean values obtained for 24-hours, or by averaging over several days.

Results of the Experiment

Measurements of meteor trail drifts were made using a coherent pulse radar on a frequency of 39.5 MHz. Transmitter power was 50 kW, pulse repetition frequency was 100 pps, main pulse width was 10 μsec, receiver sensitivity was $5 \cdot 10^{-14}$ W with the bandwidth 100 kHz. Reception and transmission was over a system of two cophased five-element antennas of

the "wave duct" type. The radar used is described in [2]. A continuous 30-day cycle of observation, from 3 January to 3 February 1966, was undertaken. The reliability of measurements by the first radar was monitored part of the time by the second radar complex. It should be pointed out that the results of simultaneous measurements of wind velocity by two diversity radars in one region of the atmosphere provide good daily correlation, as distinguished from what often is slight correlation between measurements made by one radar on successive days. /40

The results of the monthly measurements were broken down into four 5-7 day intervals:

Interval I - from 3 to 9 January;
Interval II - from 10 to 17 January;
Interval III - from 17 to 24 January;
Interval IV - from 24 January to 2 February.

The averaged characteristics of the regular wind were calculated using the harmonic expansion method for individual days, as well as for each of the four chosen intervals. The averaging of the results was done for the same hour, based on separate intervals, and for the month as a whole, computing a statistical weight for each mean monthly velocity. /41

Figure 1 shows the histograms for drifts by intervals, and Figure 2 shows the corresponding polar diagrams for variations in the vectors of the 24-hour and 12-hour harmonics.

Table 1 lists the corresponding harmonic expansion equations for the meridional and zonal components of the 24-hour histograms for drift velocities. The first row gives the drift velocity equation for one day (16 January) for comparison purposes. The rows with indices I, II, III, IV, show the histogram equations for the corresponding averaging intervals, and the last row, with index (M), lists the equation for the true mean monthly histogram. The mean errors in the expansion components also were analyzed, and were equal to:

1. for the constant term $\sigma A_0 < 2.0$ m/sec;

2. for the amplitude of the first harmonic $\sigma A_1 = 3.3$ m/sec; for the phase $\sigma\varphi_1 = 25° - 30°$;

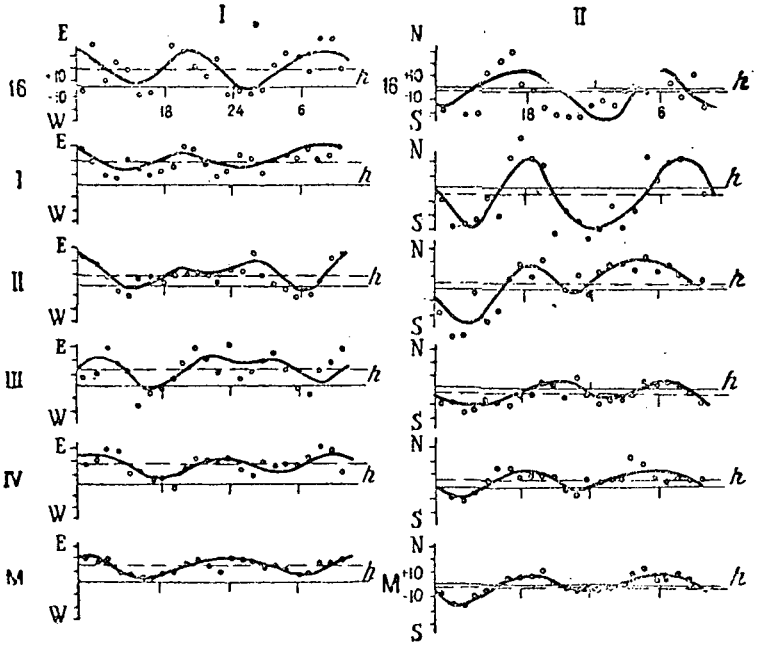

Figure 1. Histograms of drifts for a 24-hour period (16), for the intervals (I, II, III, IV), and the mean monthly histogram (M) for the monthly observation cycle.

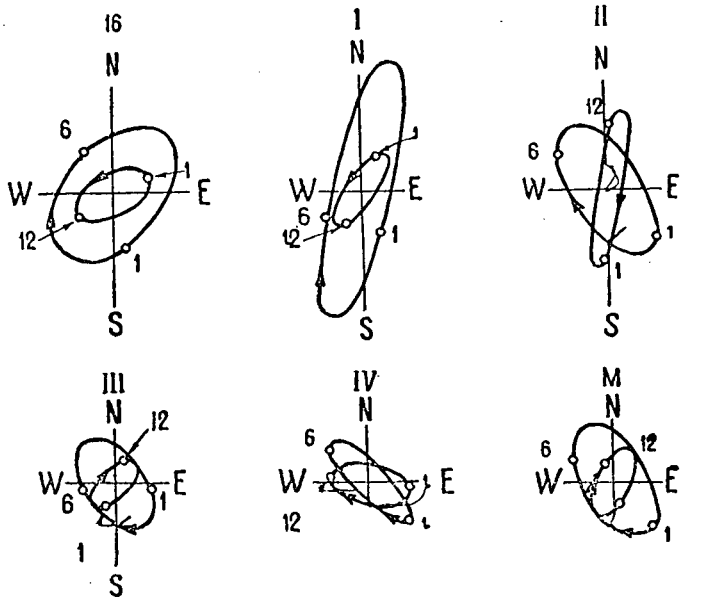

Figure 2. Polar diagrams of the vectors of the 24-hour (A_1) and the 12-hour (A_2) components for a 24-hour period (16), for the intervals (I, II, III, IV), and the mean monthly diagram (M).

TABLE 1*

Direction	Averaging interval	Type of equation
E—W	16 January	15,2+ 7,2 Sin 15 (t+ 7,1) + 12,9 Sin 30 (t+ 4,9) + 8,6 Sin 45 (t+ 6,7)
	I	21,0+ 3,6 Sin 15 (t+ 7,8) + 6,2 Sin 30 (t+ 4,4) + 2,6 Sin 45 (t+ 0,5)
	II	8,4+ 1,4 Sin 15 (t+10,3) + 9,2 Sin 30 (t+ 2,2) +11,2 Sin 45 (t+ 1,7)
	III	13,5+ 5,2 Sin 15 (t+13,2) + 9,7 Sin 30 (t+ 1,6) + 8,2 Sin 45 (t+ 7,7)
	IV	17,1+ 6,1 Sin 15 (t+ 7,7) + 6,3 Sin 30 (t+ 1,9) + 1,6 Sin 45 (t+ 6,8)
	M	14,0+ 3,0 Sin 15 (t+14,0) + 6,1 Sin 30 (t+ 2,0) + 3,2 Sin 45 (t+ 0,5)
N—S	16 January	— 5,9+ 6,1 Sin 15 (t+ 4,3) +16,4 Sin 30 (t+ 7,9) + 7,6 Sin 45 (t+ 3,3)
	I	— 6,0+ 9,3 Sin 15 (t+ 4,9) + 32,3 Sin 30 (t+ 5,6) + 9,8 Sin 45 (t+ 2,6)
	II	2,9+18,4 Sin 15 (t+15,0) + 15,5 Sin 30 (t+ 6,7) + 7,3 Sin 45 (t+ 1,2)
	III	— 6,0+ 5,9 Sin 15 (t+14,0) + 7,9 Sin 30 (t+ 5,1) + 3,7 Sin 45 (t+ 5,4)
	IV	4,1+ 4,0 Sin 15 (t+14,3) + 8,1 Sin 30 (t+ 6,9) + 2,5 Sin 45 (t+ 2,1)
	M	— 0,2+ 5,2 Sin 15 (t+13,5) + 10,0 Sin 30 (t+ 6,6) + 1,6 Sin 45 (t+ 2,9)

* Commas represent decimal points.

3. for the amplitude of the second harmonic σA_2 = 3.5 m/sec; /43
for the phase $\sigma\varphi_2$ = 15°;

4. for the amplitude of the third harmonic σA_3 = 3.3 m/sec;
for the phase $\sigma\varphi_3$ = 35°.

The deviations in the 24-hour, and especially in the 12-hour amplitudes, measured on individual days, from the mean monthly values were substantially greater than the measurement errors. It must be noted that averaging a great many days results in a relative reduction in the amplitude of the 12-hour harmonic by a factor of 1.3 to 1.5 as compared to the results for single days. An analysis of phase relationships for zonal and meridional components shows that characteristic of the 12-hour component for the month is clockwise rotation. There were virtually no changes in the phases of the harmonic expansion components in the monthly observation cycle. It can, therefore, be recommended that the phases of the harmonic expansion components be analyzed for a year, by days (excluding the spring and fall months).

Deviations in the prevailing wind, by days and by intervals, from the monthly mean are of particular interest.

Velocity Behavior of the Prevailing Wind

The majority of the deviations in the prevailing wind from the true mean monthly value exceed the measurement errors by a factor of from 2 to 3 (interval III was an exception).

Figure 3 shows the values of the prevailing wind for each day in January for the meridional and zonal components.

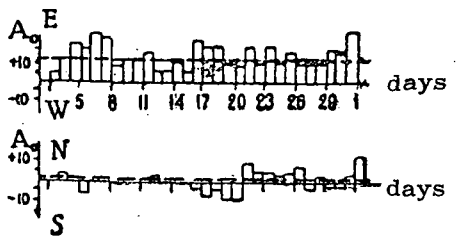

Figure 3. Mean values of the prevailing wind, A_0, by days in January.

There were substantial deviations in the prevailing wind on a day-to-day basis during the month, going well beyond the limits of measurement errors. These obviously were not due to instrument effect, but were associated with chaotic fluctuations in the prevailing wind from day to day. /44

Figure 4 is the vector diagram of the variations in the prevailing wind, A_0, from 16 to 31 January, and can be used to follow the periodicity in the variations in the A_0 vector. The X is the mean monthly value of the prevailing wind vector. Muller notes a similar periodicity, one with a period of from 3 to 9 days [3].

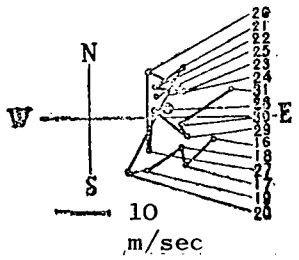

Figure 4. Vector diagram of variations in A_0, between 16 and 31 January. X - the mean monthly position of the A_0 vector.

Figure 5 shows the autocorrelation function of deviations in the daily ΔA_0 values for zonal components of the velocity of the prevailing wind from the monthly mean with measurement errors.

The autocorrelation function, the value of which was calculated for the mean daily deviation for 29 days, has a periodic component with a period of 9 to 11 days, and an amplitude commensurate with the 12-hour harmonic. A shift of one day will result in a decrease in the correlation coefficient to the magnitude of the periodic component. Evidently, even if there are random jumps, they occur during a time interval of less than one day and appear as random oscillations in the

amplitudes and phases of the 24-hour harmonics. A more detailed analysis of the correlation bonds between fluctuations A_0 was made by constructing an autocorrelation function for deviations in mean hourly velocities for each day from the smoothed curve of means for six days of observations, obtained by harmonic expansion, including three periodic harmonics.

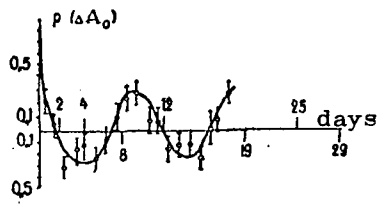

Figure 5. Autocorrelation function of daily deviations in the ΔA_0 value from the monthly mean (for the zonal component of the prevailing wind).

Slow variations in A_0 during this period of observation also were included. Thus, we attempted to separate possible fluctuations in wind velocity from well-studied regular variations. Figure 6 is the autocorrelation function of random hourly deviations obtained during six days of continuous observations, together with errors in the determination of the correlation coefficient. The clear correlation of fluctuations in intervals of less than 24-hours is evident. This agrees with the preceding conclusions (see Figure 5). /45

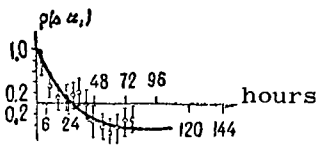

Figure 6. Autocorrelation function of random hourly deviations during six days of continuous observations.

The consolidation of the results of several days of observations is important primarily as a means of obtaining the mean monthly characteristics, including possible and irregular many-day variations in wind characteristics.

The 9 to 11 day oscillations in the prevailing wind that we noted can serve as an additional argument in favor of the incorrectness of taking measurements of meridional and zonal wind components on days that do not coincide. Everything said leads to the recommendation that the following organization of the service be used to study seasonal behavior patterns: measurements to be taken 4 or 5 times a month, with 1-1/2 days in each interval (a two day and one night, interval), with observations distributed uniformly over the whole monthly cycle. This organization of the observations will permit following variations in A_0 during the month, season, and

year, and make possible an attempt to establish a correlation with the variables in the lower layers of the atmosphere.

All of which poses for the experimenters the problem of using more detailed investigations of 24-hour variations in the prevailing wind to develop a statistically more correct method of determining the mean monthly parameters of the regular wind.

REFERENCES

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2. Karimov, K. A., Kostromin, V. D., Berezovskiy, M. I., "The Radar Installation for Observing Meteors in Kirghizia," Sb.: Meteornoye rasprostraneniye radiovoln [In collection: Meteor Propagation of Radio Waves], Parts 3-4, Kazan', 1966.

3. Muller, H. G., "Atmospheric Tides in the Meteor Zone," Planetary and Space Science, Greenwich, 14, No. 12, 1966.